

THE WEATHER AND CIRCULATION OF JUNE 1955¹

ILLUSTRATING A CIRCUMPOLAR BLOCKING WAVE

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1. INTRODUCTION

During the first 6 months of 1955 the hemispheric weather pattern was seldom entirely free of blocking activity. This was particularly true of June, when the blocking could easily be associated with the unusually cool weather over the United States. This was a reversal from the general temperature regime of May [1] and was accompanied by one of the lowest zonal index values (5-day mean) ever recorded.

It is the purpose of this article to examine in turn: the outstanding monthly circulation characteristics including the half-monthly features and changes, the United States weather in light of the above, and a week-by-week evaluation of a pronounced blocking surge as revealed by 5-day mean maps and anomalies at 700 mb. This blocking surge was somewhat unusual in that one could trace its effects about the Pole for almost two complete revolutions.

2. MONTHLY AND HALF-MONTHLY CIRCULATION FEATURES

Indications of blocking activity are quite evident on the mean 700-mb. map for June, figure 1. In the Atlantic the westerlies were well south of normal with weakly above-normal heights over Iceland. These were connected by way of Davis Strait to the maximum anomaly of the month, a positive departure of 310 ft. over eastern Hudson Bay. This appears to have been the mean locus of blocking activity. In the middle-latitude trough along the east coast of the United States heights were below normal in the usual sense of high-low latitude compensation. Enhanced cyclonic activity, depression of westerlies, and colder-than-normal temperature regime south and east of the blocking center were also typical of the usually expected relationships.

Over North America the westerly flow was much weaker than normal except at very low and high latitudes—a feature closely associated with the split jet streams which are common to some definitions of blocking. And, a split jet was quite evident on the mean maps at higher levels (Charts XIV and XV).

Circulation changes over the Pacific have been relatively

small the last few months. Heights have maintained above normal in a nearly zonal band which has been about parallel to and north of the subtropical ridge axis. In consequence, Pacific winds have been stronger than normal at latitudes north of the axis of positive anomaly. In June this northward displacement was most marked in the eastern Pacific, while the intensification of 700-mb. westerlies was about the same in eastern and western sections (up to 7 m/sec. greater than normal).

The Aleutian Low was at about normal intensity, and the western Pacific and eastern Asiatic troughs were near their normal locations. At sea level (Chart XI) one also could see the enhancement and northward shift of the westerlies in the eastern Pacific.

Blocking traces were again evident in Asia where heights were 240 ft. above normal and sea level pressures 4 mb. above normal in the anticyclone northeast of the Caspian Sea. Over Europe and the Norwegian Sea heights were not far above normal but at sea level a ridge of high pressure stretched from northern Greenland to the Mediterranean.

The 15-day 700-mb. means for the first and last halves of June afford further insight into the general trend of events. During June 1-15, (fig. 2A) blocking was most prevalent and intense from the Norwegian Sea westward through central Canada (heights +360 ft.). The westerlies were far south of normal and a zonal band of below normal heights reached from eastern Europe to the Central Plains of the United States. This continued depression of the westerlies appeared to be an extension of the trend begun during the latter half of May [1] when similar but less marked characteristics were present. Such tendencies are strongly opposed by the northward seasonal trend of the westerlies.

Short wave spacing, truncated troughs, cut-off Lows, and warm higher-latitude Highs characterized the area from central Europe through North America. Asia and the Pacific appeared less affected. Indeed the polar westerlies were exceptionally strong over most of Asia—a direct reversal from the latter half of May [1].

During the latter half of June (fig. 2B) blocking relaxed over the Atlantic and Europe. While blocking continued over North America (heights 260 ft. above normal over Hudson Bay) heights rose at lower latitudes and many of

¹ See Charts I-XV following p. 137 for analyzed climatological data for the month.

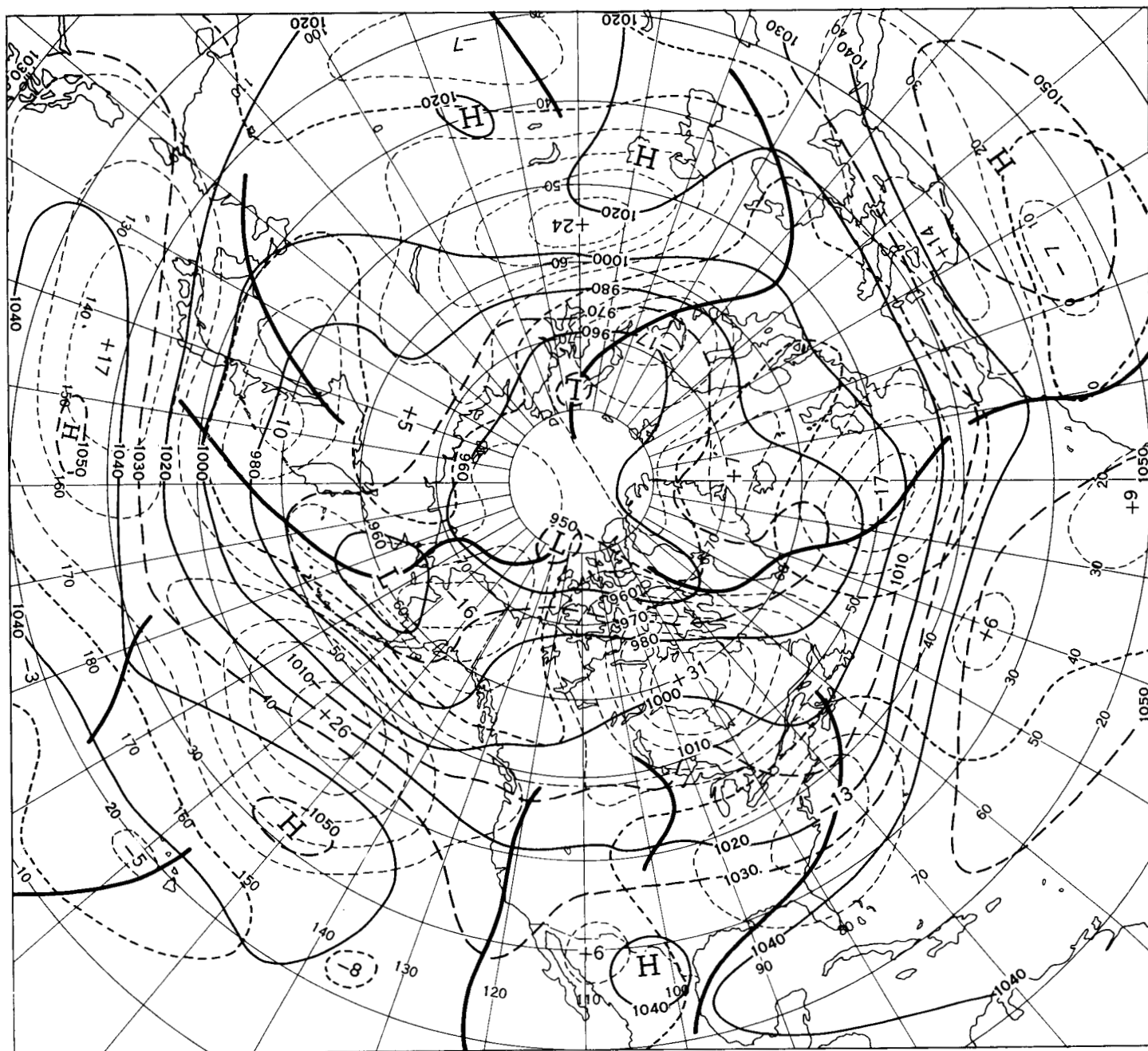


FIGURE 1.—Mean 700-mb. contours and height departures from normal (both in tens of feet) for May 31–June 29, 1955. Effects of blocking are apparent in the depressed Atlantic westerlies, are most marked over North America (heights 310 ft. above normal over Hudson Bay and 130 ft. below normal off Cape Hatteras), inconspicuous in the Pacific, but again observable in the positive anomaly stretching east-northeastward from the Caspian Sea.

the concomitants of strong blocks weakened or disappeared. However, quite strong blocking activity was centered in eastern Asia where split jet, cut-off Low, and warm High were present.

Thus, blocking dominated the European, Atlantic, and North American sectors during the first half-month, never entirely inverted the Pacific circulation, but strongly influenced Asia during the second half-month.

3. UNITED STATES WEATHER AND ANOMALIES

The below normal temperatures of June were the most noteworthy feature of the weather this month. Temperatures averaged 4° F. or more below normal in a wide belt from North Carolina to the Central Plains (Chart 1-B). In parts of the northern border States from North Dakota to New England temperatures were above normal, as they

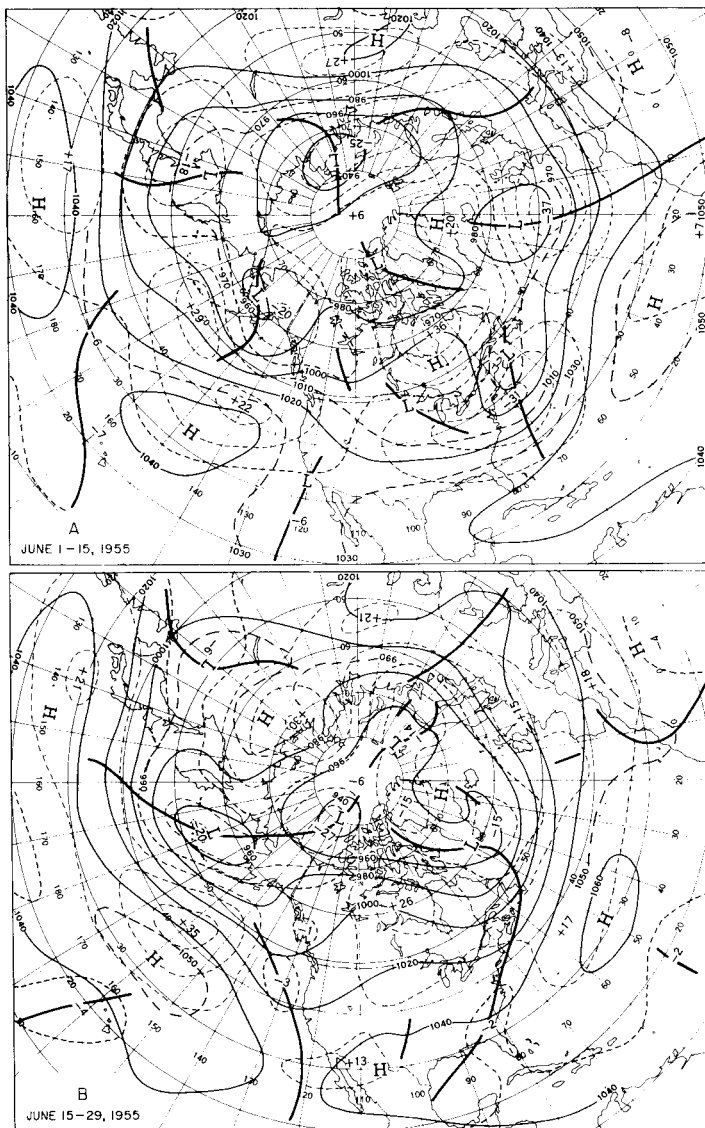


FIGURE 2.—Mean 700-mb. contours and height departures from normal (both in tens of feet). (A) June 1-15, 1955. Blocking strongly affected the area from the Norwegian Sea through central Canada. Twin cyclonic vortices at middle latitudes show the westerly reaction to Atlantic blocking. Truncated troughs and poorly defined flow pattern characterized western North America. Cold air from Canada, and cyclonic activity kept the eastern two-thirds of the United States unseasonably cool. (B) June 15-29, 1955. Blocking was still operative over North America but considerable recovery was evident over Atlantic sections as the westerlies worked northward. Blocking was most strongly marked over Asia where heights were 300 ft. above normal in the anticyclone northeast of Lake Baikal.

were also in the upper Columbia and Snake River Valleys and along the Rio Grande. All other areas recorded below normal temperatures.

Extremely cool conditions were noted the first half-month when the blocking was most intense over Canada, and slow-moving cyclonic developments over the central United States were followed by cool Canadian air. The

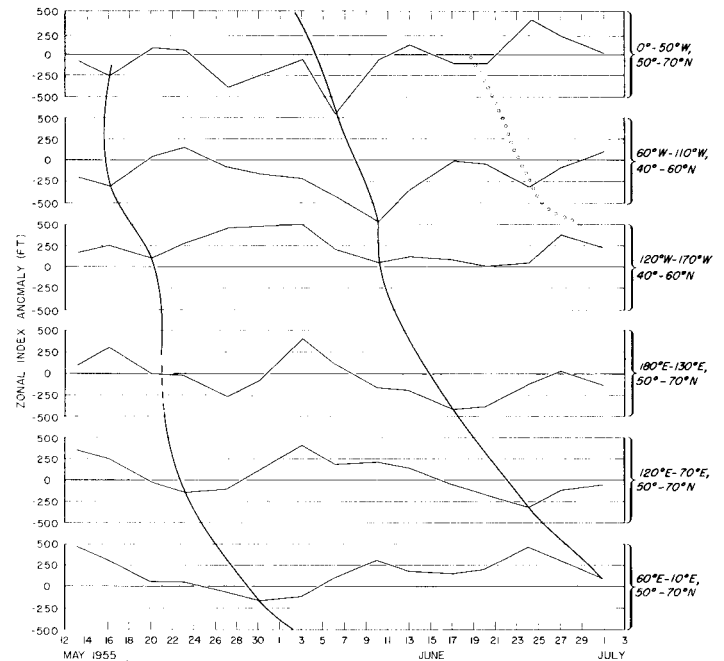


FIGURE 3.—Five-day mean circumpolar zonal index anomalies at 700 mb. by 60° longitude bands for indicated latitudes. (Note, an anomaly of +500 ft. represents about 6.1 m/sec. anomalous westerly flow for 40°-60° N., and 5.4 m/sec. for 50°-70° N.) Mean values are plotted at mid-date of period. Sloping lines show progressive upstream diminution of westerlies, usually to below normal values, and trace retrogression of blocking surge. Dots show secondary abortive block of late June.

cloudiness attendant on the cyclones depressed maximum temperatures and the Highs which swept down in their rear kept temperatures below normal. In the Central Plains temperatures averaged 10°-12° F. below normal the week ending June 12. During the 5-day period June 8-12 the zonal westerlies (0°-180° W. and 35°-55° N.) dropped to a value of 3.2 m/sec., the lowest zonal index of record in June (last lower value of record: 3.1 m/sec. for May 4-8, 1946). During the following week, extreme conditions moderated somewhat but temperatures still averaged some 8°-9° F. below normal over the southern Appalachians.

In contrast to the marked cold weather in the East, June 1-15 provided about the first extensive warm spell over the Far West since the beginning of the year. This could be associated with the disappearance of the west coast trough at middle latitudes as heights rose above normal and general anticyclonic conditions prevailed aloft. Also, the strongly divergent pattern over western North America permitted only very limited advection of cool maritime air from the Pacific, with the major migratory systems affecting western Canada rather than the United States. The highest temperature during this warm spell was 100° F. recorded at Seattle on June 9—an all-time June maximum for that station.

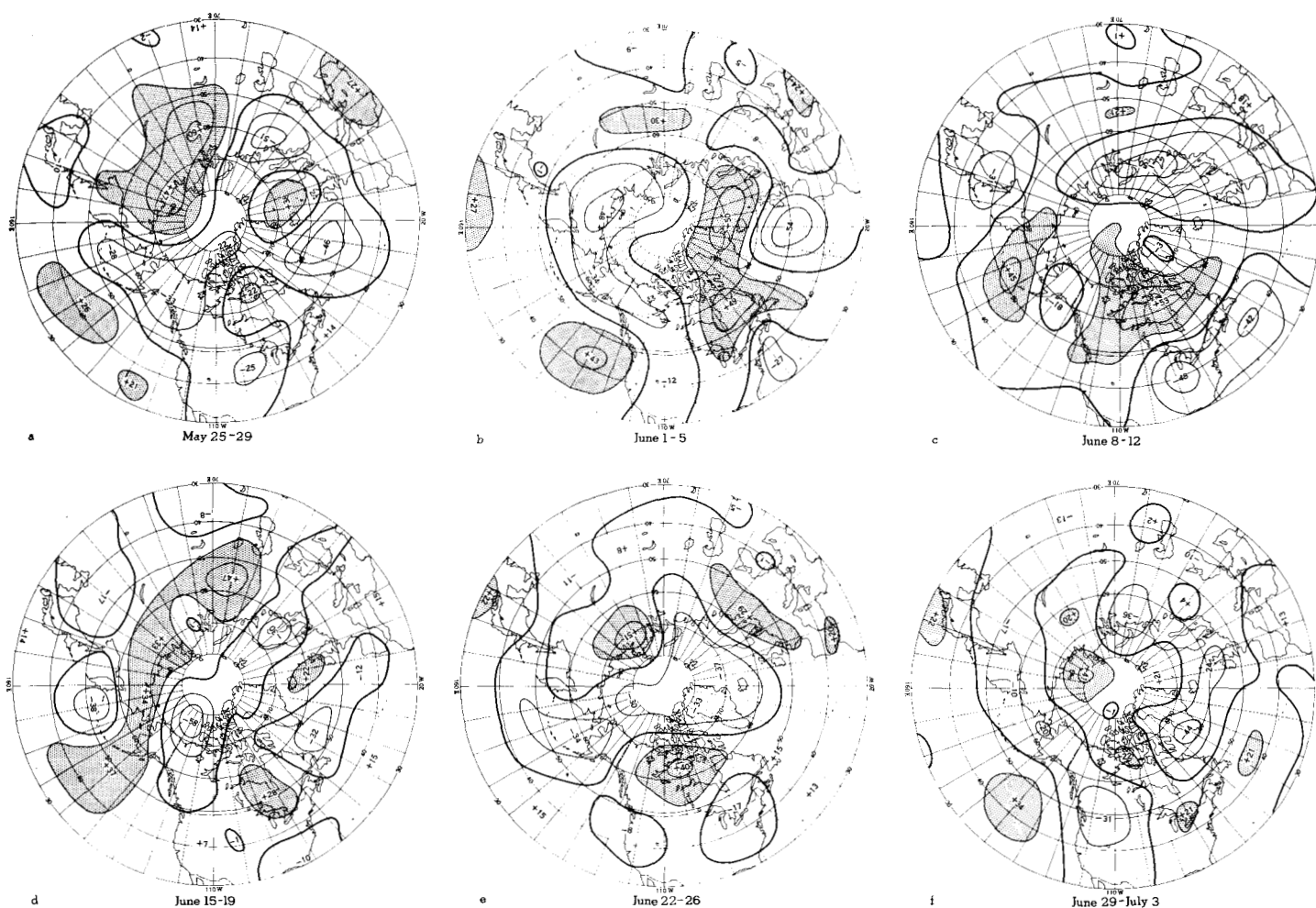


FIGURE 4.—Series of 5-day mean 700-mb. height departures from normal (in tens of feet). Isopleths are for 200-ft. intervals with positive anomalies greater than 200 ft. shaded. Note spread of positive anomalies from Asia westward until they appear to spiral in to the Pole.

Other early June weather items included a dust storm with winds of 55 m. p. h. at San Angelo, Tex. on the 8th, cloudbursts and flash floods in Nevada on the 13th, and scattered tornado activity.

During the second half of June there were two features of principal interest. One was the reactivation of the west coast trough with stronger than normal maritime flow affecting the West. This restored below normal temperatures over the Far West where they have been prevalent most of the year. The second was the persistent, although weakened, block centered over Hudson Bay which continued to effect below normal temperatures from the Central Plains eastward through the Carolinas. The departures were less than in early June but the general pattern of anomaly (east of the Rockies) was strikingly similar.

This persistent temperature pattern over the eastern two-thirds of the United States was part of the strong reversal in temperatures which took place between May and June. In the West, the two contrasting half-months produced a considerable net change from the May anom-

alies. As a consequence, this year has been unusual in its departures from the recent course of month-to-month persistence [2].

From April to May 1955 [1] persistence was exceptionally marked (98 percent of stations in 0+1 class change), whereas in recent years April-May comparisons have shown a preponderance of temperature reversals. The same records show on the average about 70 percent persistence (0+1 class change) from May to June. This year only 35 percent persistence—about one-half the average—was noted. These deviations from the recent monthly sequences are all the more interesting in light of the extension of these data to some 60 years of record by Enger [3]. His data show low April-May but quite high May-June temperature persistence. In this light also, 1955 has been quite anomalous.

The prevalence of blocking with its diversion of storms to the south was conducive to fairly widespread precipitation over the United States. In contrast to the early summer droughts of recent years there was nearly adequate precipitation during June over almost all of the

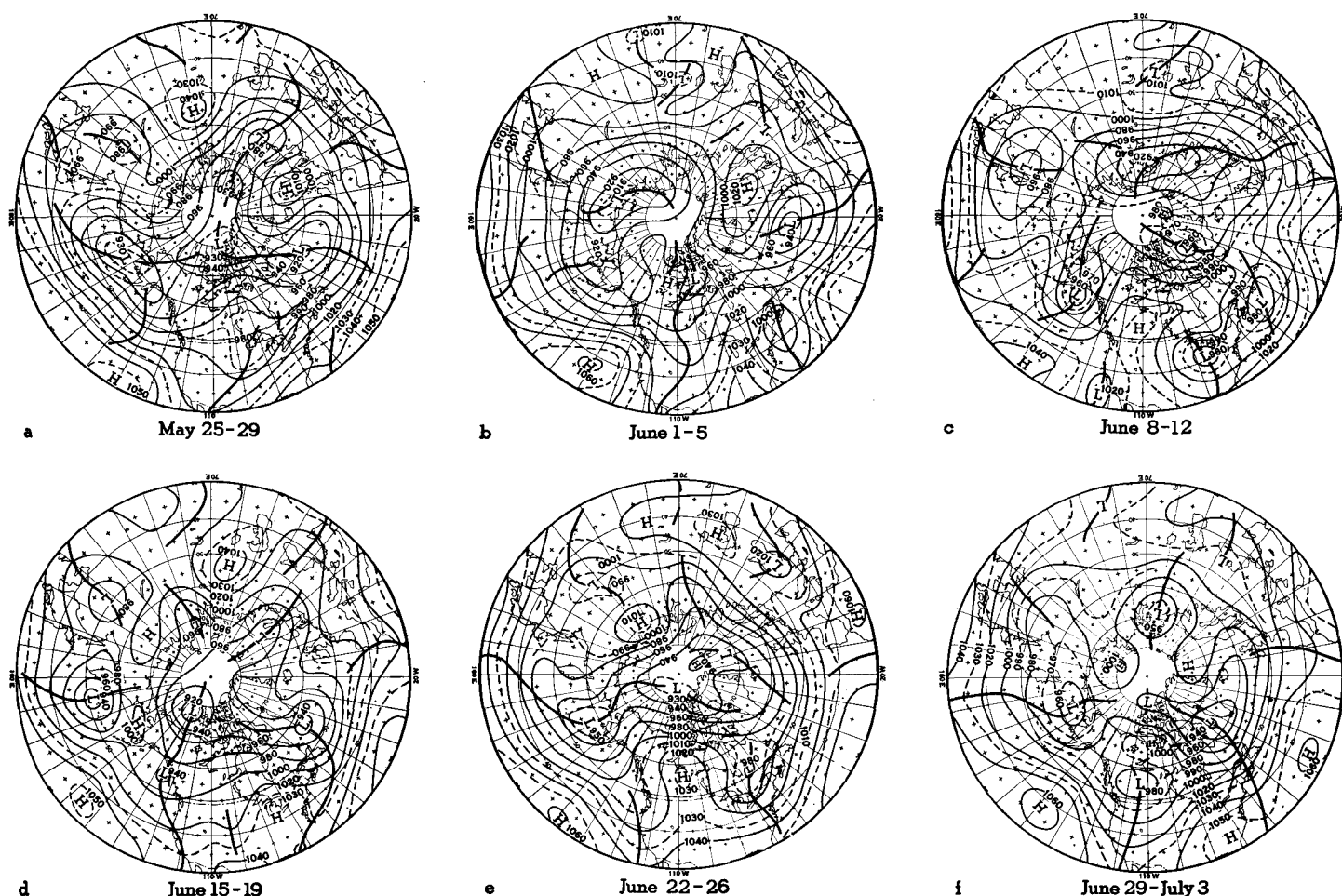


FIGURE 5.—Series of 700-mb. 5-day mean maps corresponding to dates of figure 4. Heights are in tens of feet. The retrogression of blocking across the Atlantic in early June is easily discernible and its effects on lower latitudes may be regarded as almost classic. Pacific reaction to blocking was less marked (c and d) although Asiatic response was quite strong (e).

United States. Although reserves of ground moisture were fairly low in some areas, crops were generally in excellent condition and a near-record yield seemed likely.

Severe weather was reported in numerous localities but most noteworthy was the 10 to 20 inches of rain which fell over part of southeastern Wyoming. This occurred in connection with a rash of tornadoes and hailstorms which also affected Nebraska June 26-27. These brought the threat of flooding to the placid North Platte River for the first time in many years.

4. A CIRCUMPOLAR BLOCKING SURGE

The overall prominence of blocking activity this June was sufficient to evoke general comment. As indicated previously, it had no uncertain role in the cool June temperatures over the United States and, judging from newspaper accounts, it could be associated with drought and forest fires in south central Canada.

The outstanding characteristics of blocking have been long recognized, e. g., Garriott [4], Namias [5], and its synoptic and climatological features delineated, e. g.,

Elliott and Smith [6], Rex [7], Sanders [8], and Sumner [9]. However, there has been only a slow growth in emphasis upon the retrogressive phenomena commonly called blocking surges, blocking waves, blocking action, etc.

Most meteorologists who have studied hemispheric weather changes for any considerable period of time have agreed that following the initiation of a block one can often, but not invariably, trace changes in the circulation which occur progressively upstream. Garriott mentioned the slowing down of migratory systems over North America following stagnation and anticyclogenesis in the Atlantic and Europe. Willett found small but positive one-week lag correlations (zonal index) between the Atlantic and North America [10]; Namias [2] illustrated this effect by showing the progressive upstream diminution in the 10,000-foot zonal index and the accompanying accretion of mass of air above 10,000 feet for 2 cases in early 1944. Berggren, Bolin, and Rossby [11] demonstrated similar retrogressive phenomena on daily charts. Early theoretical models by Rossby [12, 13] and Yeh [14] were proposed to account for these phenomena.

However, there is also rather general agreement among synopticians that blocking effects are propagated upstream in various forms and at various speeds, i. e., the whole warm High may retrograde—either bodily or “discontinuously”, the next upstream trough may fill at higher latitudes and deepen at lower latitudes, the next upstream ridge may project meridionally into high latitudes and/or in turn become a warm blocking High, or it may join at least partially the initial blocking High by arching over the intervening trough, or heights may simply rise (upstream) at higher latitudes and fall farther south without singular 700-mb. circulations being set up.

Neither the exact timing nor type of reaction can as yet be predetermined from the pre-state. In view of the various modes of activity and variations in time and latitude of reactions, it is not surprising that rigid statistical testing has not revealed any unique sequence of events [6, 7]. This series of articles has, where appropriate, reviewed outstanding cases of blocking [15, 16] and tried to emphasize their retrogressive character. May-June of 1955 affords another such opportunity.

Figure 3 presents the evidence of blocking in terms of 5-day mean zonal index variations (about the local normal at 700 mb.) similar to those of Namias [2]. These sectional indices (60° longitude wide) encompass the globe. The 20° latitude bands used (indicated on fig. 3) have been chosen to maximize the blocking wave of June.

The block is shown initially affecting areas from 0° – 110° W. in mid-May, after which progressive diminution of the sectional indices, usually to below normal (negative) values, occurred. The “minimum” 180° – 130° E. around May 21 was not well marked and could be better demonstrated at lower latitudes, but only at the expense of the June surge. The retrogression of blocking action slowed down over Asiatic-European sectors during late May [1] but travelled rapidly across the Atlantic-North American sectors in early June. Some retardation was also evident in late June, again over the Asiatic-European sectors. In all but one section (eastern Pacific) the line denoting the second passage of the blocking surge passes through the minimum of the index values for the month. A minor secondary surge which affected the Atlantic-North American sectors in late June has been denoted by dots. One may observe that westerlies (40° – 60° N.) were seldom above normal for the entire period between 60° W. and 110° W. In contrast the westerlies in the sector immediately upstream (120° W.– 170° W.) were never below normal due to the persistent strength and orientation of the eastern Pacific High.

Although the index graphs of figure 3 are completely objective once the areas are chosen, they suffer the obvious deficiency of portraying the phenomenon in a severely constrained and segmented fashion. A more comprehensive picture of developments may be gained by studying the fields of mean height departure from normal, mean height change, 700-mb. temperature

anomaly, or the 700-mb. circulation pattern itself. Two of these aspects have been included in this report: the 5-day mean height departures from normal and the 700-mb. mean circulation patterns. Because of space limitations only the last complete revolution of the blocking is shown.

Figure 4a, May 25–29, shows tremendous positive height anomaly over Asia, with heights already above normal from Greenland to Scandinavia as blocking began to affect that area. One week later (fig. 4b), above normal heights reached from Scandinavia to Hudson Bay with heights strongly below normal in the central Atlantic. During June 8–12 the block centered over North America with two intense lower-latitude cyclonic vortices. This was an almost classical blocking retrogression. (See following article by Robinson and Joseph where the effect of blocking on the motion of two Lows is discussed.) Blocking had also begun to affect the Pacific as the Gulf of Alaska Low filled and ridging extended northwestward through the Bering Sea. By June 15–19 blocking had relaxed over North America and the eastern Pacific. It now appeared from the central Pacific through Asia to the center northeast of the Caspian Sea. During June 22–26 the block failed to affect significantly the European circulation while heights were still some 510 ft. above normal in northern Siberia. In the period June 29–July 3 the block appeared to spiral in toward the Pole and further continuity of this type became difficult if not impossible.

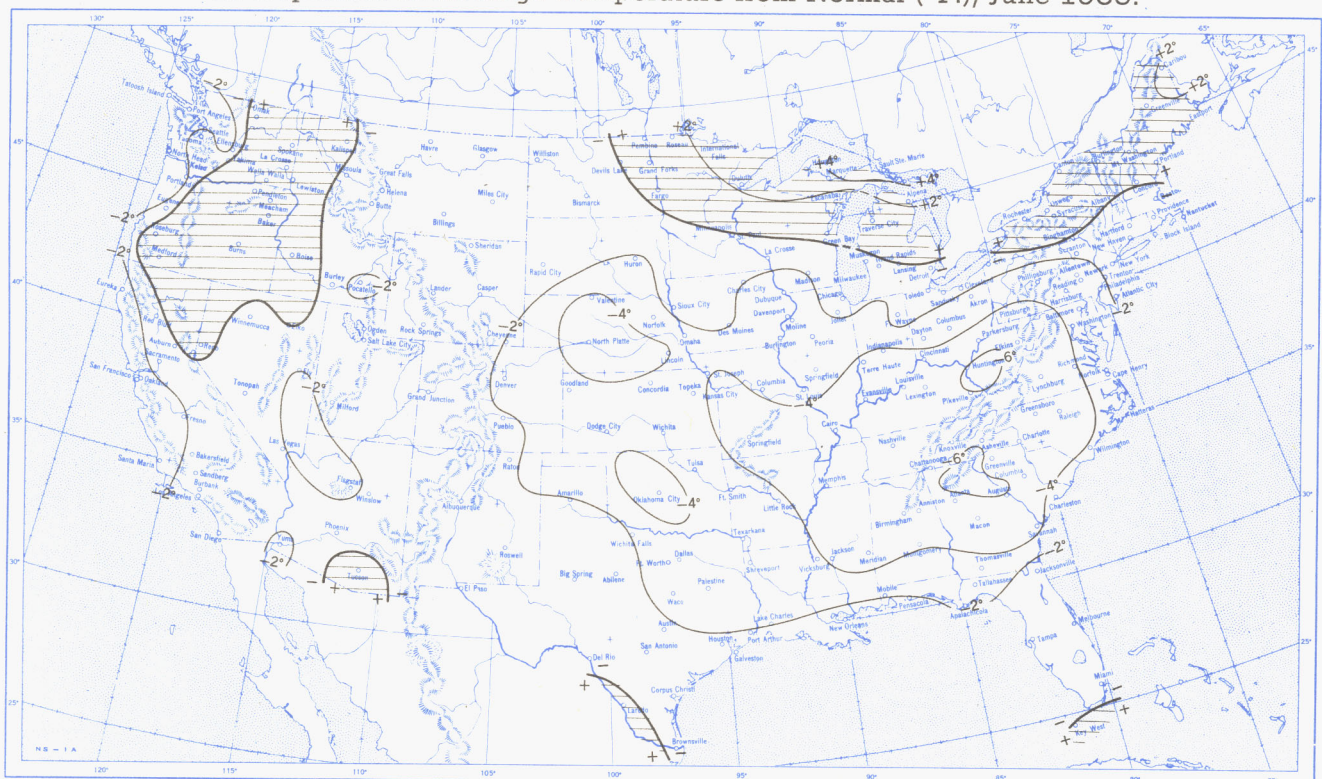
Figures 5a–f show the corresponding 700-mb. circulation patterns. Figure 5a shows the Highs over central Asia and between Iceland and Norway. In 5b the western High has become dominant with a deep Low to its southwest and a weak Low to the southeast. The ridge over the United States was building and during the following half-week, June 4–8 (not shown) it connected across the Davis Strait with the retrogressive blocking center. In figure 5c the block was central over North America with closed vortices at lower latitudes; note however, ridging was already occurring in the Bering Sea. June 15–19 (fig. 5d), shows the block in the Pacific but only a rather weak anticyclonic arch from Alaska through northern Siberia. June 22–26 (fig. 5e) saw the remainder of the block over northern Asia, the secondary blocking surge centered over North America, and strong westerlies from the western Atlantic to western Russia. The last map (fig. 5f) shows a rather unusual arrangement of three anticyclones at high latitudes as the blocking seemed to be shunted northward while a fairly well-organized westerly regime operated to the south.

The recent prevalence of blocking and its intimate connection with higher-latitude pressure rises versus lower-latitude falls cannot but recall the somewhat similar responses associated with increasing solar activity by many researchers in this field. It may be pertinent to point out that this was a period of increasing sunspottedness. Mean Zürich spot numbers (provisional) for Janu-

ary through June 1955 read: 20.0, 20.8, 4.7, 11.3, 29.6, and 33.1. May and June were months of moderate spottedness following a pronounced minimum (the 11-year minimum occurred in 1954). The blocking activity in December 1943 through March 1944 illustrated by Namias took place at just about the minimum in the 11-year spot cycle, but slightly on the descending (long range) side. There has been no direct evidence produced here of any connection between sunspots and blocking, but the general similarity of their effects suggests a relationship which may have to be examined further if the theoretical models prove unable to satisfactorily anticipate blocking phenomena. The only evidence bearing on this subject which has yet come to light is presented in a recent article by Bolin [17] which seems to indicate that even a simple 72-hour barotropic forecast can catch the development of a warm higher-latitude High from an initial state characterized by well-marked wave amplitudes. Whether the initial buckling from a flat westerly flow can be equally well forecast is a question which has not yet been answered.

REFERENCES

1. C. M. Woffinden, "The Weather and Circulation of May 1955—Alleviation of Drought in the Midwest," *Monthly Weather Review*, vol. 83, No. 5, May 1955, pp. 104–109.
2. J. Namias, "The Annual Course of Month-to-Month Persistence in Climatic Anomalies," *Bulletin of the American Meteorological Society*, vol. 33, No. 7, Sept. 1952, pp. 279–285.
3. I. Enger, "Month-to-Month Persistence," *Bulletin of the American Meteorological Society*, vol. 36, No. 1, Jan. 1955, pp. 36–37.
4. E. B. Garriott, "Long-Range Weather Forecasts," U. S. Weather Bureau, *Bulletin No. 35*, Washington, D. C., Oct. 1904, p. 62.
5. J. Namias and P. F. Clapp, "Studies of the Motion and Development of Long Waves in the Westerlies," *Journal of Meteorology*, vol. 1, Nos. 3 and 4, Dec. 1944, pp. 57–66.
6. R. D. Elliott and T. B. Smith, "A Study of the Effects of Large Blocking Highs on the General Circulation in the Northern Hemisphere Westerlies," *Journal of Meteorology*, vol. 61, No. 2, April 1949, pp. 67–85.
7. D. F. Rex, "Blocking Action in the Middle Troposphere and its Effect upon Regional Climate," Parts I and II, *Tellus*, vol. 2, Nos. 3 and 4, Aug. and Nov. 1950, pp. 196–211 and 275–301.
8. R. A. Sanders, "Blocking Highs over the Eastern North Atlantic Ocean and Western Europe," *Monthly Weather Review*, vol. 81, No. 3, March 1953, pp. 67–73.
9. E. J. Sumner, "A Study of Blocking in the Atlantic-European Sector of the Northern Hemisphere," *Quarterly Journal of the Royal Meteorological Society*, vol. 80, No. 345, July 1954, pp. 402–416.
10. R. A. Allen, R. Fletcher, J. Holmboe, J. Namias, and H. C. Willett "Report on an Experiment in Five-Day Weather Forecasting," *Papers in Physical Oceanography and Meteorology*, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution, vol. 8, No. 3, April 1940, pp. 51–53.
11. R. Berggren, B. Bolin, and C.-G. Rossby, "An Aerological Study of Zonal Motion, Its Perturbations and Break-Down," *Tellus*, vol. 1, No. 2, May, 1949, pp. 14–37.
12. C.-G. Rossby, "Dispersion of Planetary Waves in a Barotropic Atmosphere," *Tellus*, vol. 1, No. 1, Feb. 1949, pp. 54–58.
13. C.-G. Rossby, "On the Dynamics of Certain Types of Blocking Waves," *Journal of the Chinese Geophysical Society*, vol. 2, No. 1, June 1950, pp. 1–13.
14. T. C. Yeh, "On Energy Dispersion in the Atmosphere," *Journal of Meteorology*, vol. 16, No. 1, Feb. 1949, pp. 1–16.
15. W. H. Klein, "The Weather and Circulation of May 1954—A Circulation Reversal Effected by a Retrogressive Anticyclone During an Index Cycle," *Monthly Weather Review*, vol. 82, No. 5, May 1954, pp. 123–130.
16. A. F. Krueger, "The Weather and Circulation of January 1954—A Low Index Month with a Pronounced Blocking Wave," *Monthly Weather Review*, vol. 82, No. 1, Jan. 1954, pp. 29–34.
17. B. Bolin "Numerical Forecasting with the Barotropic Model," *Tellus*, vol. 7, No. 1, Feb. 1955, pp. 27–49.

Chart I. A. Average Temperature ($^{\circ}\text{F.}$) at Surface, June 1955.B. Departure of Average Temperature from Normal ($^{\circ}\text{F.}$), June 1955.

- A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
- B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

Chart II. Total Precipitation (Inches), June 1955.

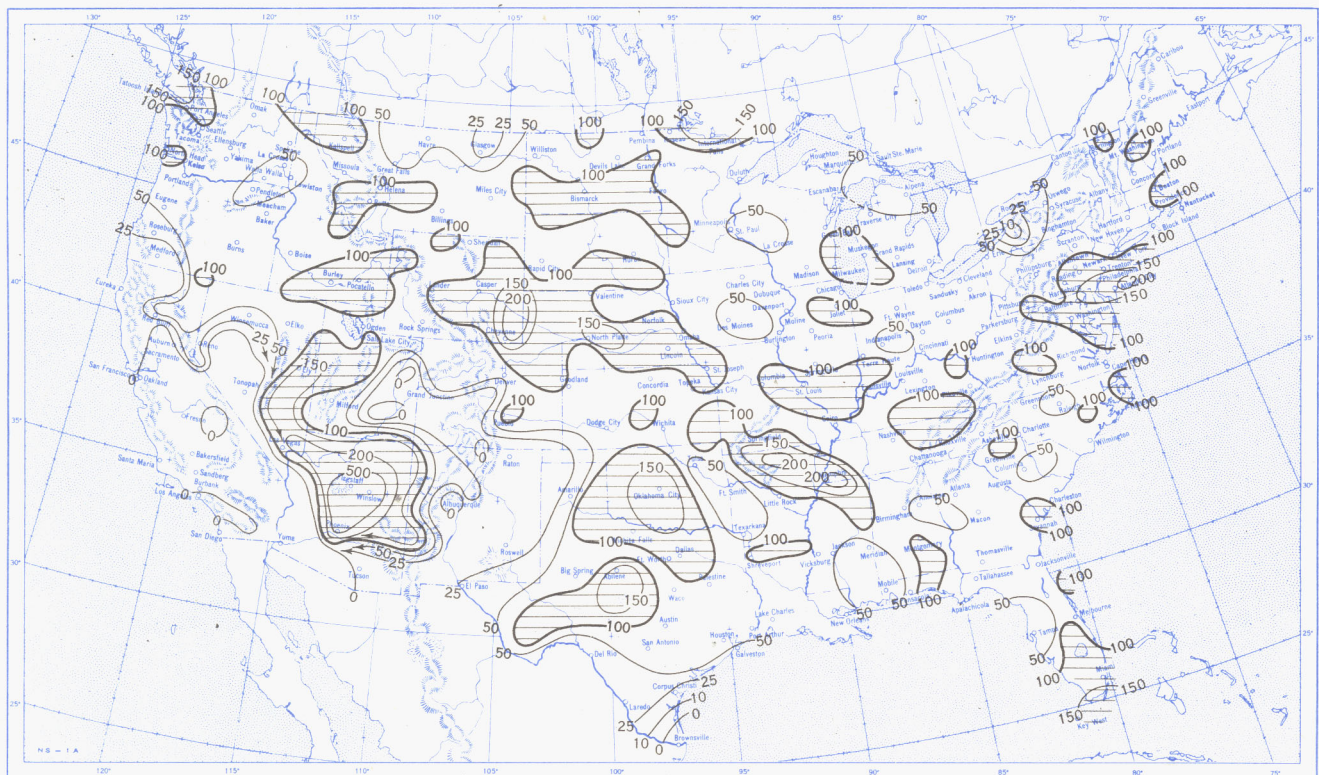


Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), June 1955.

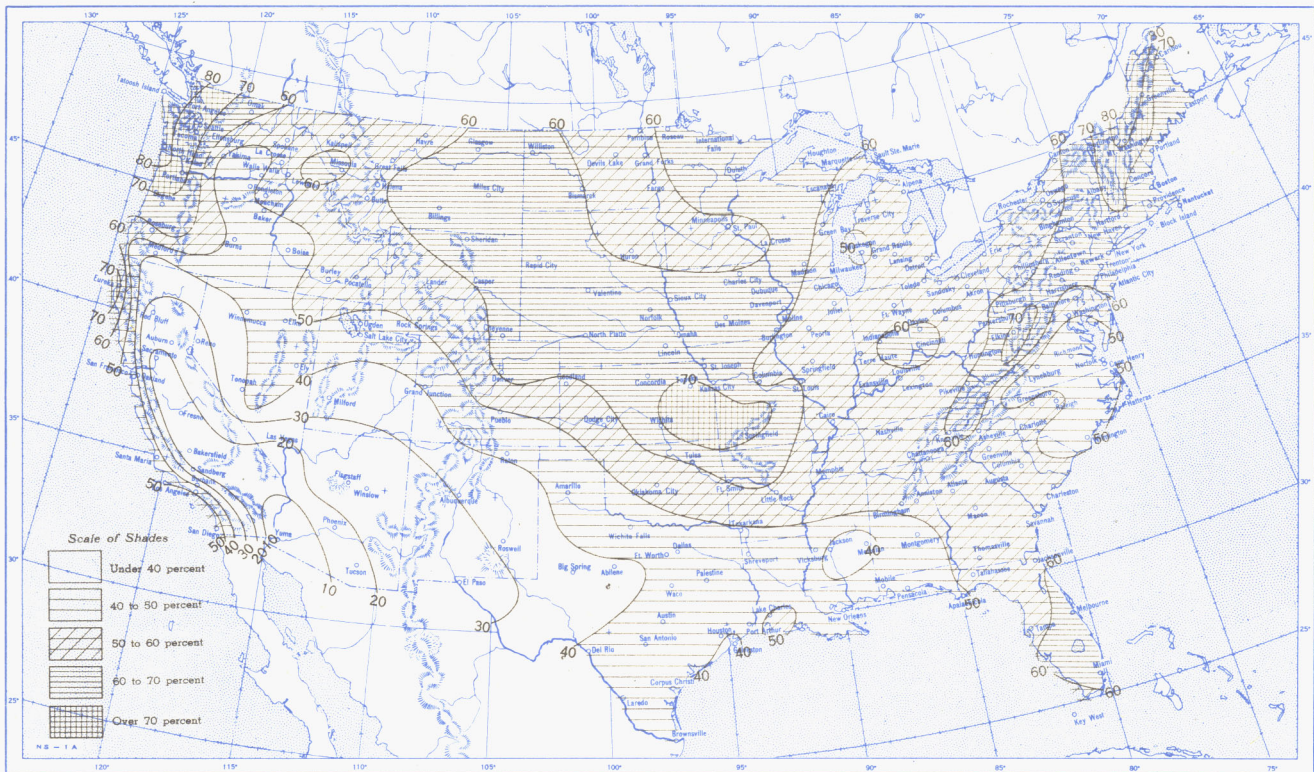


B. Percentage of Normal Precipitation, June 1955.

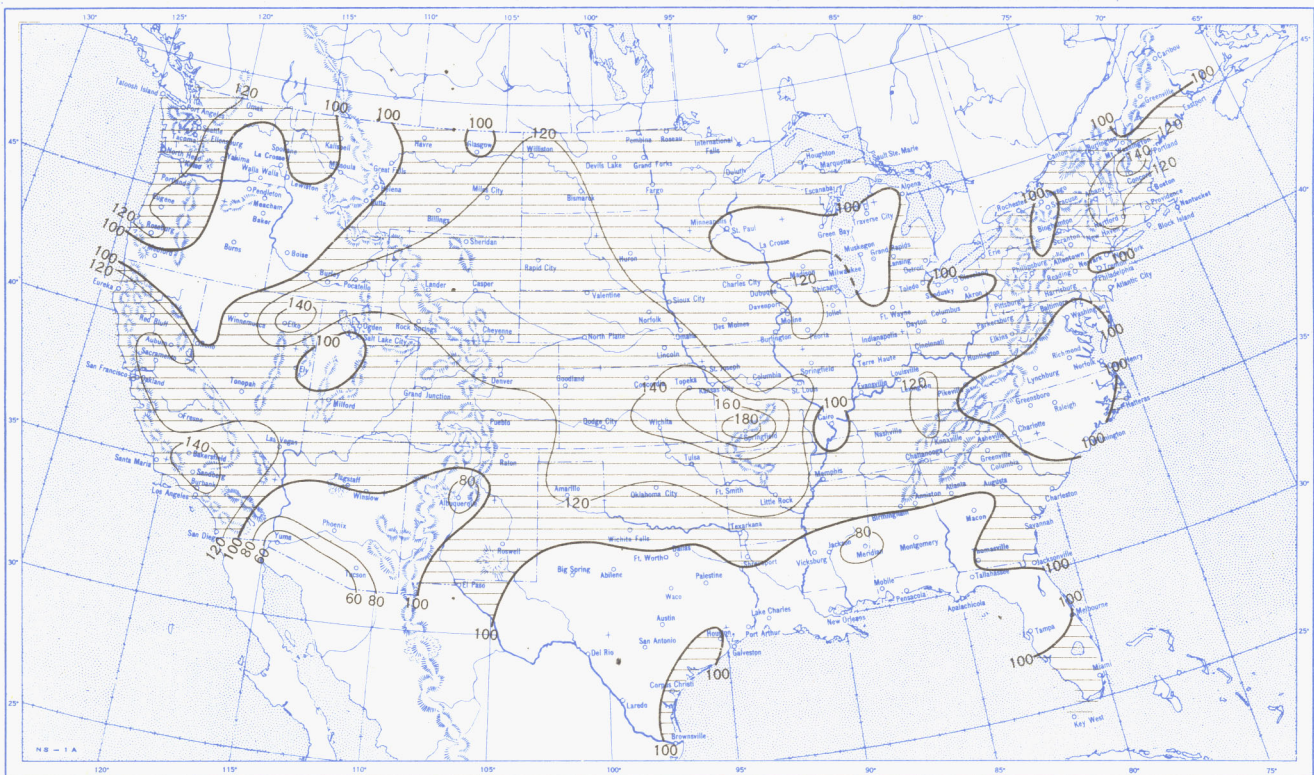


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, June 1955.

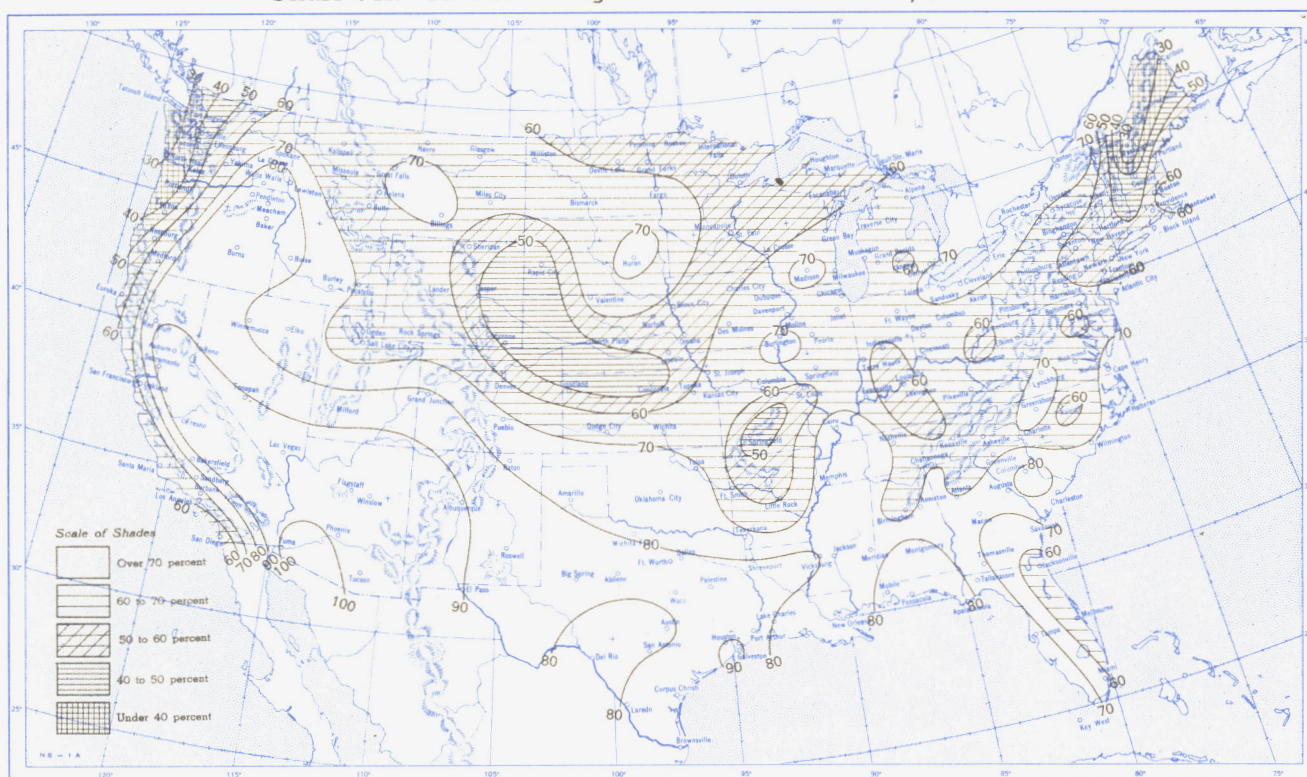


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, June 1955.

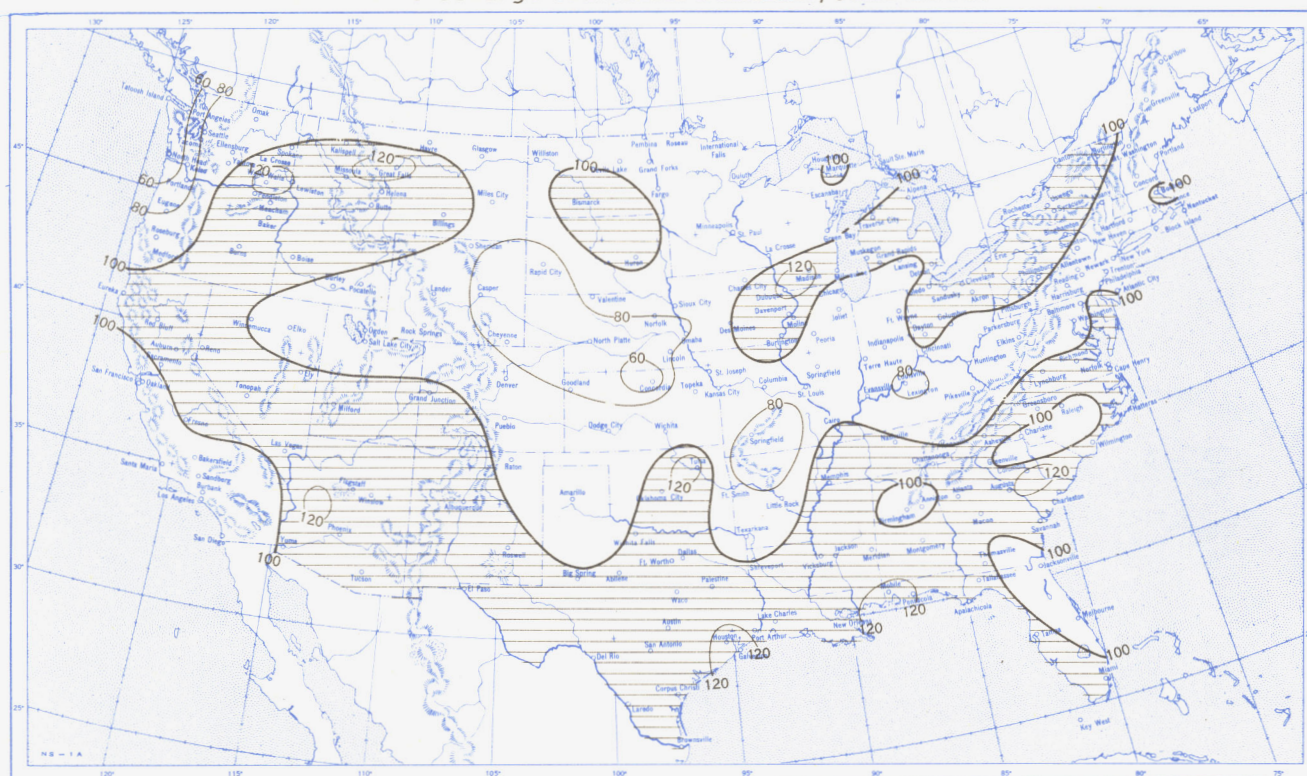


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, June 1955.



B. Percentage of Normal Sunshine, June 1955.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, June 1955. Inset: Percentage of Normal Average Daily Solar Radiation.

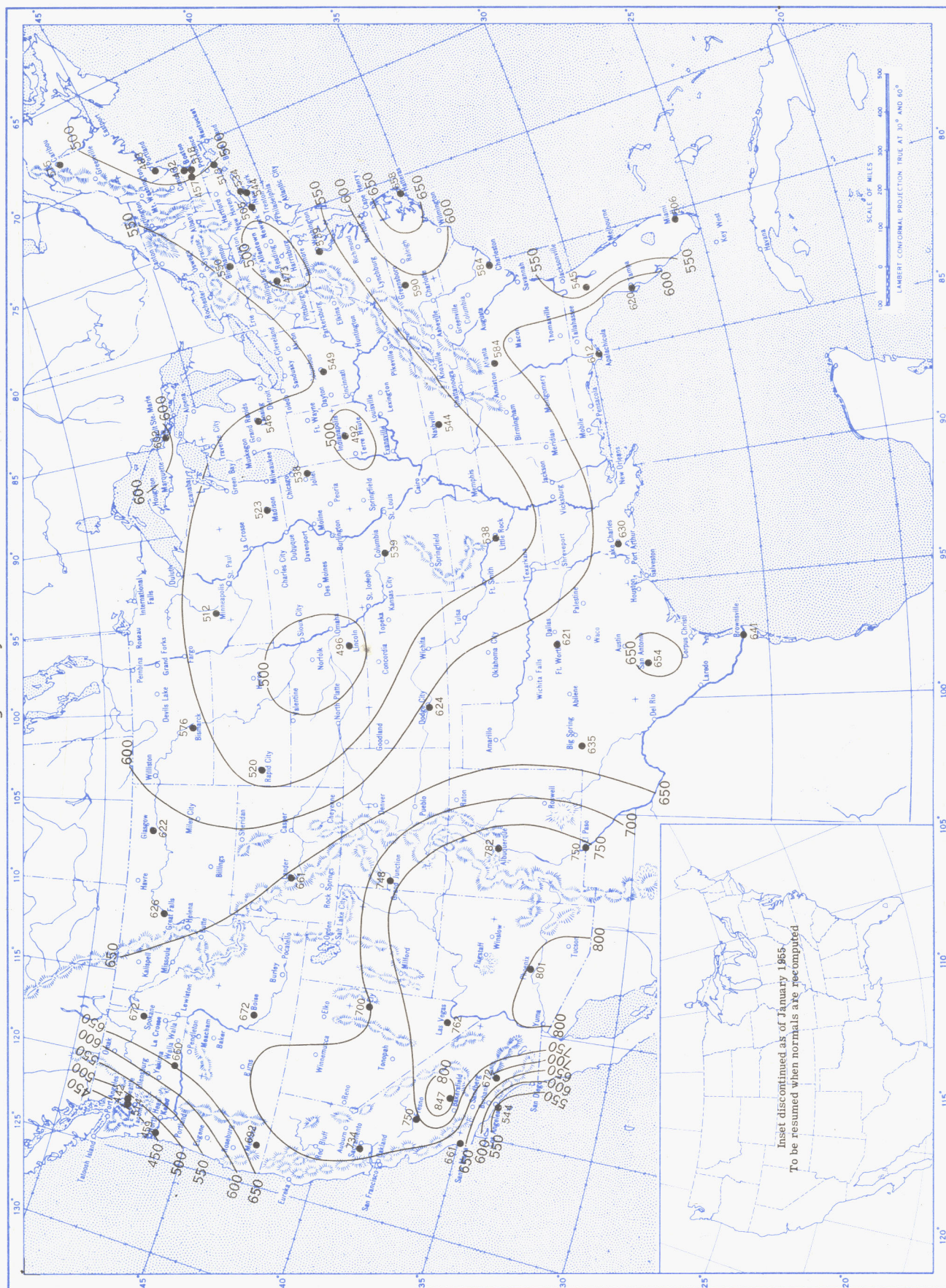


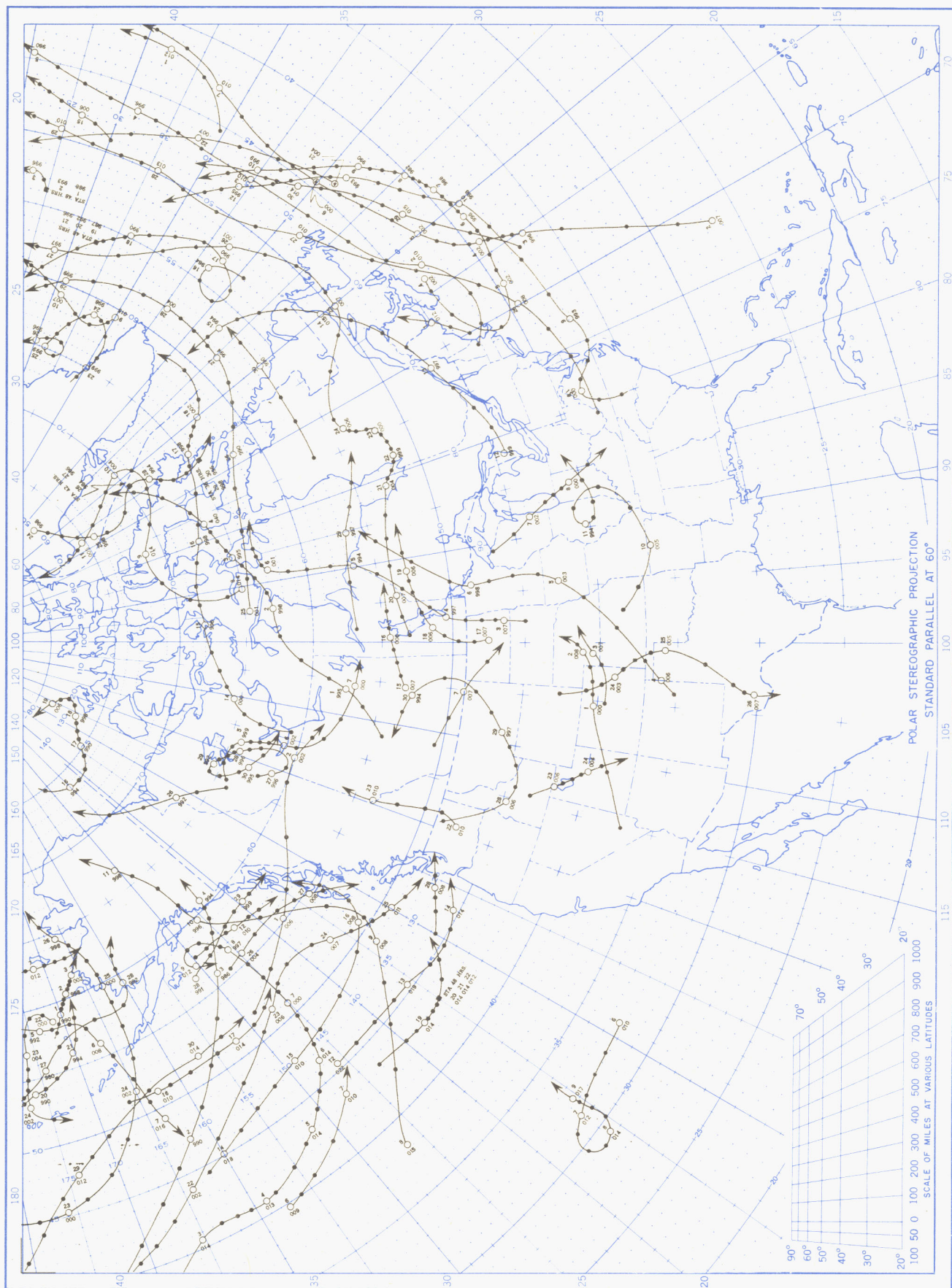
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langley (1 langley = 1 gm. cal. cm.⁻²). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, June 1955.



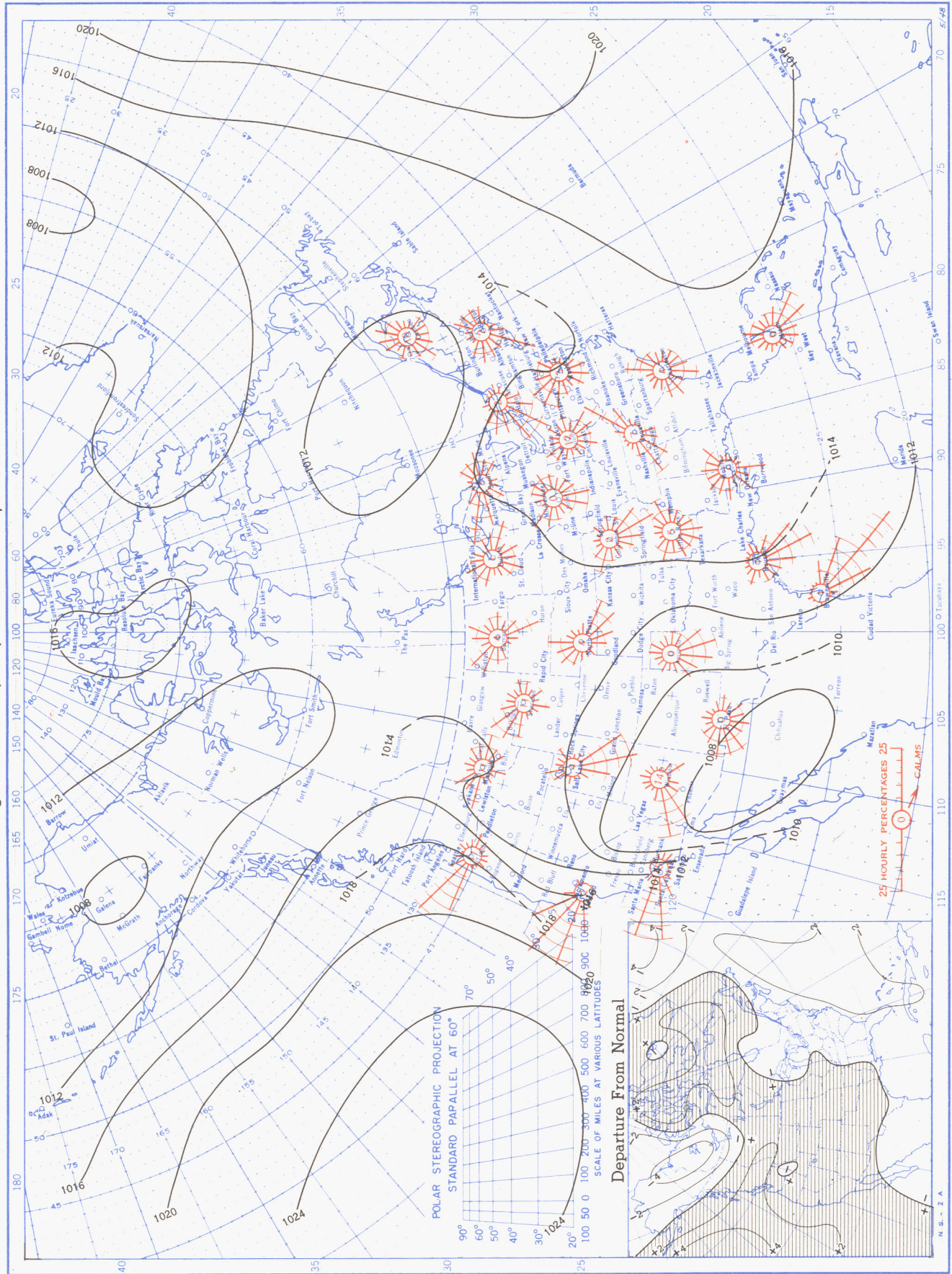
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar.
Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, June 1955.



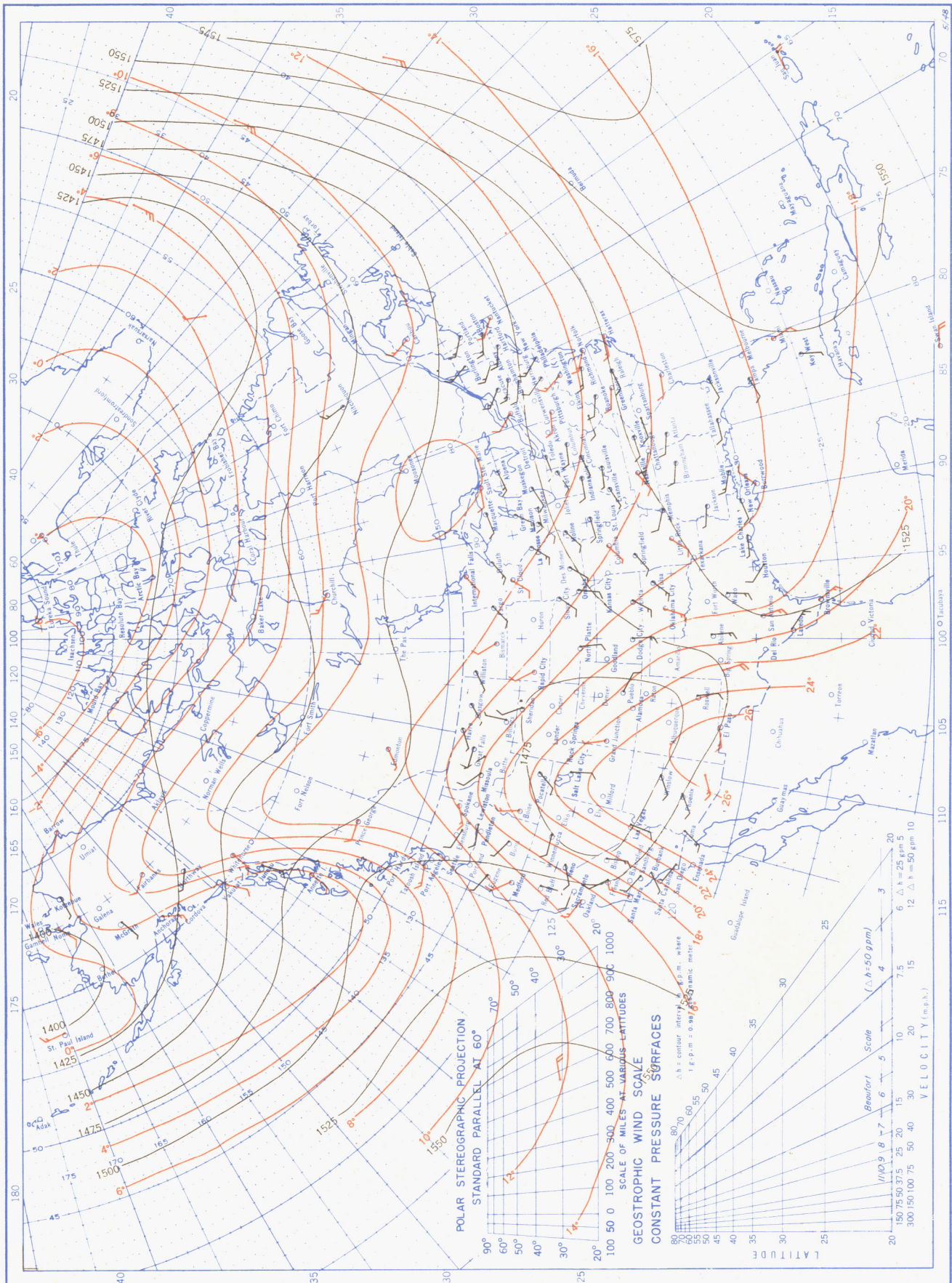
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, June 1955. Inset: Departure of Average Pressure (mb.) from Normal, June 1955.



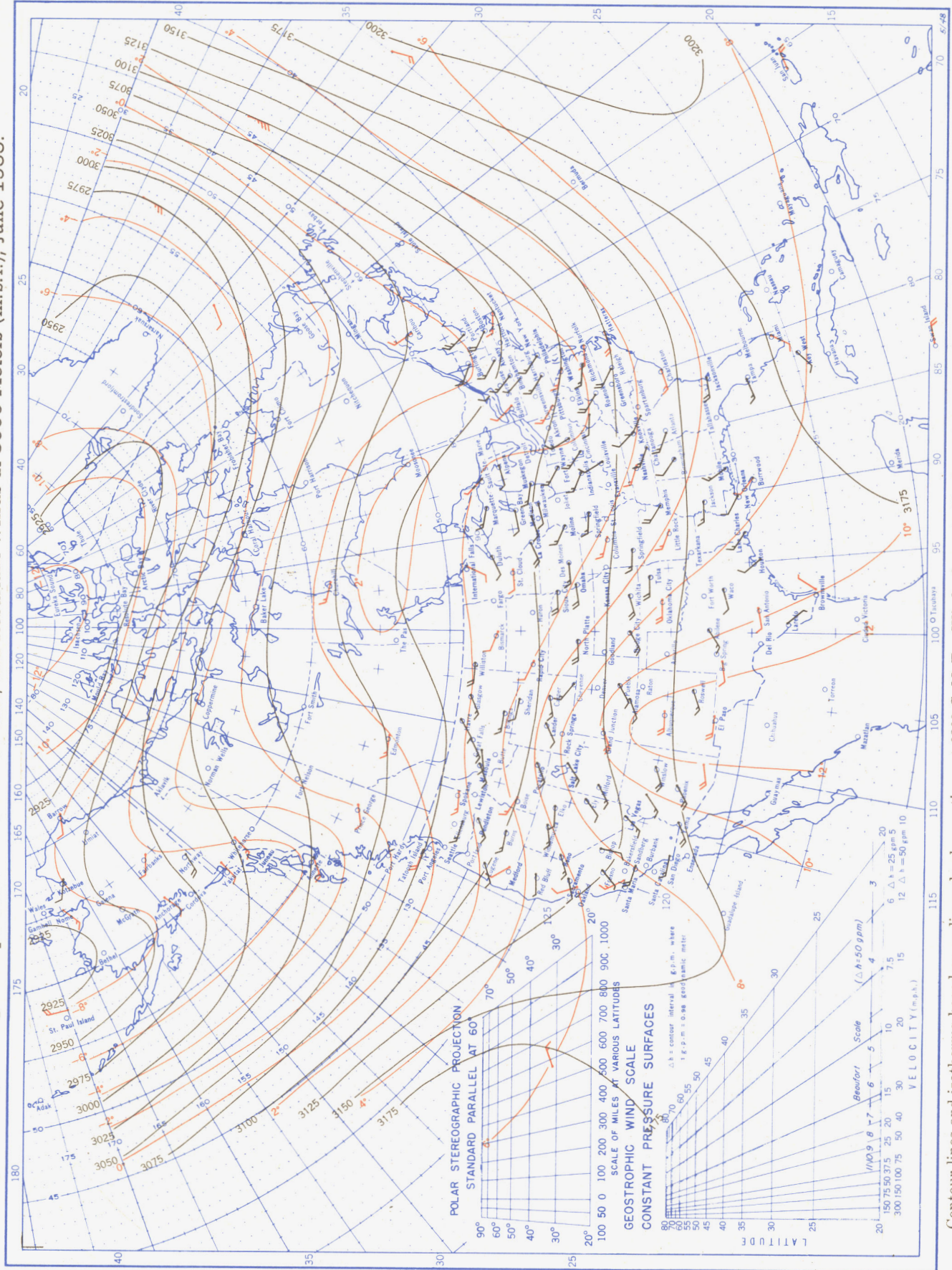
Average sea level pressures are obtained from the averages of the 7:30 a. m. and 7:30 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° inter-sections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), June 1955.



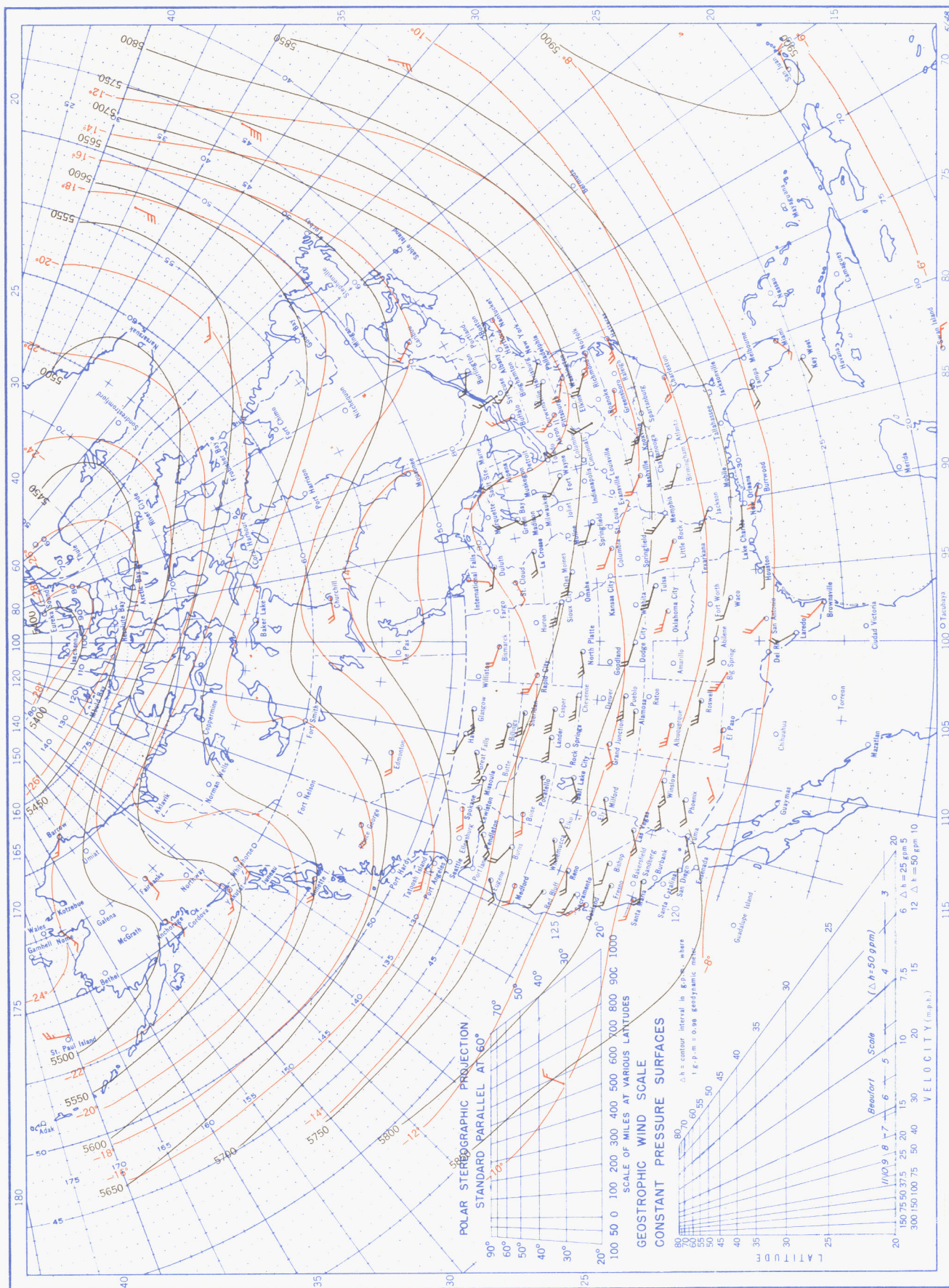
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), June 1955.



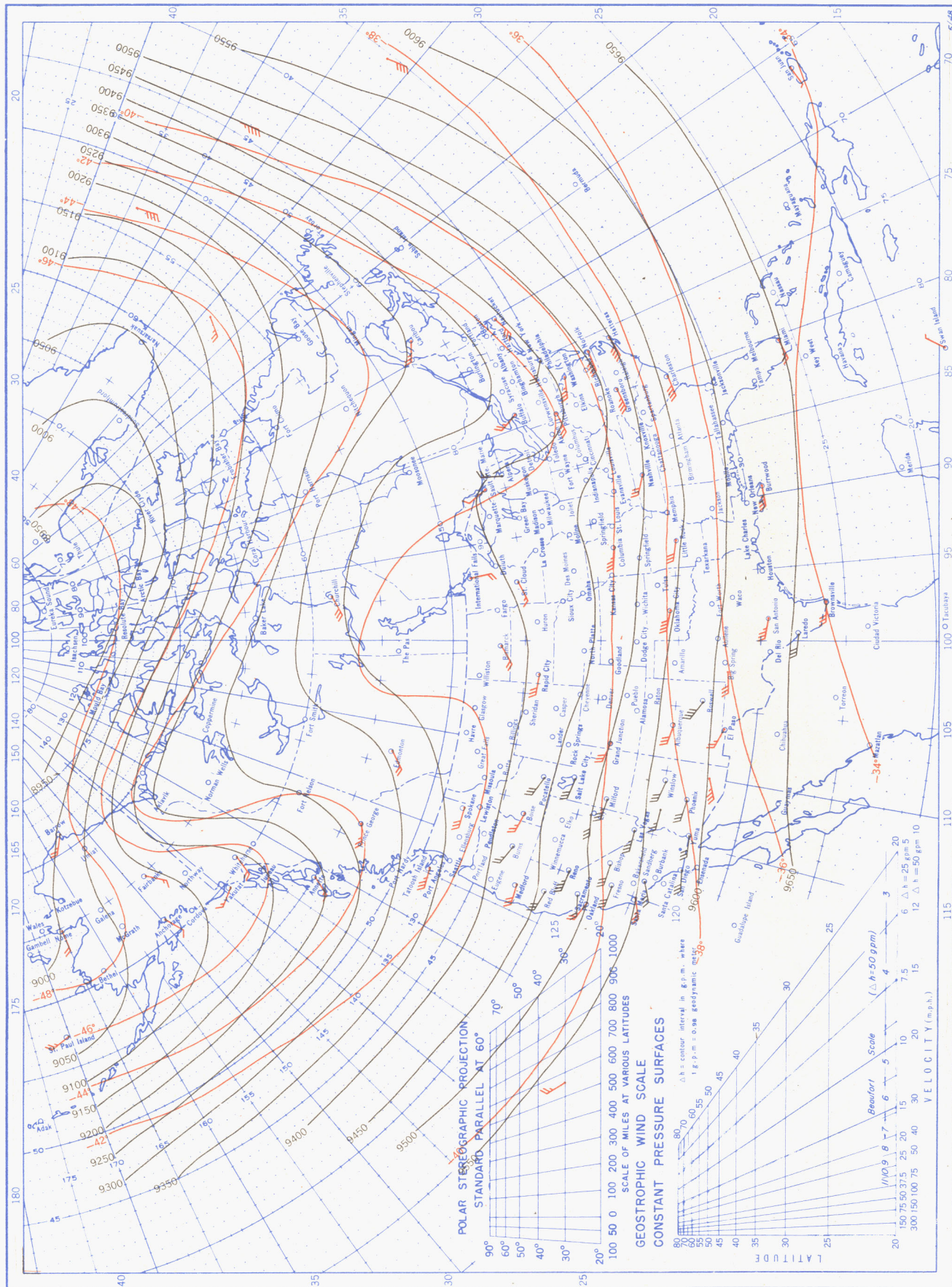
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0000 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), June 1955.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), June 1955.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.